Extending the Late Holocene White River Ash Distribution, Northwestern Canada

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ABSTRACT. Peatlands are a particularly good medium for trapping and preserving tephra, as their surfaces are wet and well vegetated. The extent of tephra-depositing events can often be greatly expanded through the observation of ash in peatlands. This paper uses the presence of the White River tephra layer (1200 B.P.) in peatlands to extend the known distribution of this late Holocene tephra into the Mackenzie Valley, northwestern Canada. The ash has been noted almost to the western shore of Great Slave Lake, over 1300 km from the source in southeastern Alaska. This new distribution covers approximately 540000 km² with a tephra volume of 27 km³. The short time span and constrained timing of volcanic ash deposition, combined with unique physical and chemical parameters, make tephra layers ideal for use as chronostratigraphic markers.

Key words: chronostratigraphy, Mackenzie Valley, peatlands, White River ash

INTRODUCTION

Tephra travels away from the source volcano in plumes determined by the prevailing wind direction at the time of eruption. Fine-grained tephra may travel hundreds of kilometres before being deposited. In distal environments, lake sediments and peat preserve tephra deposits only a few millimetres thick. Such thin deposits, which may represent very powerful eruptions, are normally impossible to trace with certainty in subaerial exposures because of post-depositional mixing and weathering processes. Thus, the known extent of tephra-depositing events can often be greatly expanded through the observation of ash in peatlands (Lowe, 1988; Zoltai, 1988; Holmes et al., 1999). Tephra, or primary fallout debris, typically comprises compact (and occasionally bedded) layers of varying particle size, from fine macroscopic ash to medium lapilli. These pale-coloured, unweathered layers are often visible against darker lake sediments and peat (Fig. 1). The short span and constrained timing of volcanic ash deposition, combined with unique physical and chemical parameters, make tephra layers ideal for use as chronostratigraphic markers in lakes or peatlands (Robinson and Moore, 1999).

Peatlands are a particularly good medium for trapping and preserving tephra, as their surfaces are wet and well vegetated. In distal areas, thin ashfalls do not generally kill the vegetation, and the ash is retained and incorporated into the peat as it grows vertically. Peatlands are generally not subject to the same scale of erosion, rooting, and aeolian processes that may hamper long-term preservation in other environments. Peat-forming mosses grow from their tips and have no roots, removing preservation problems due to bioturbation that may be found in forests or areas with woody or herbaceous vegetation. Zoltai (1988) suggests that peat prevents the settling, or downward translocation, of tephra. The downward percolation of water and runoff in upland soils also tends to prevent preservation where the tephra is thin.

Volcanic ash layers in western Canada have proved to be very important chronostratigraphic markers in providing age control for a variety of geomorphic processes, including alluvial fan growth (Ryder, 1971), slope processes (Osborn and Luckman, 1981; Harris and McDermid, 1998), fluvioglacial aggradation and incision (Dawson, 1889; Fuller, 1986), glacier (Rampton, 1970) and rock glacier fluctuations (Dyke, 1990), lake level fluctuations (Clague,
1981), and peatland growth (Capps, 1915; Rigg and Gould, 1957; Tarnocai, 1973; Zoltai and Johnson, 1985; Zoltai, 1988; Ovenden, 1990; Robinson and Moore, 1999, 2000). Tephra layers in peat have been used extensively in the past for chronostratigraphic correlations in Canada (Zoltai, 1988), the United States (Rigg and Gould, 1957), Great Britain (Holmes et al., 1999), New Zealand (Lowe, 1988), the former Soviet Union (Braitseva et al., 1997), and Japan (Yabe, 1993).

THE WHITE RIVER ASH

The White River ash layer is one of the more northerly of the Holocene tephras present in western Canada, and was first noted by Schwatka in 1883 (Schwatka, 1898). It is characterized as a Plinian eruption, of explosive power and with a widely dispersed rhyodacite ash (Hanson, 1965) composed of glass, plagioclase, hornblende, hypersthene, and magnetite (Lerbekmo and Campbell, 1969). Two separate lobes (see Fig. 2) were first noted by Bostock (1952), and likely have Mt. Churchill, Alaska, as their source (Richter et al., 1995). The smaller lobe trends northwards along an axis just west of the Alaska-Yukon boundary and is found as far north as the Yukon River. This lobe has been dated at between 1900 and 1500 $^{14}$C years ago (Lerbekmo and Campbell, 1969; Hughes et al., 1972; Lerbekmo et al., 1975). A younger, larger lobe trends east from the source. Detailed radiocarbon dating suggests an age of 1147 calendar years before 1950 (a date of A.D. 803) for this lobe (Clague et al., 1995). Workman (1979) and Moodie et al. (1992) suggest that the ashfall from the eastern lobe triggered human population displacements that led to Athapaskan migrations eastward into the Mackenzie Valley and southward into northern British Columbia.

Published maps of the White River ash distribution suggest that the ashfall did not extend as far as the Mackenzie Valley (Bostock, 1952; Hughes et al., 1972; Lerbekmo et al., 1975; Clague et al., 1995), with only the map of Richter et al. (1995) suggesting that the easterly extent might be much greater. However, several researchers have observed the ash in peatlands and lakes at various locations in the Mackenzie Valley (Rowe et al., 1974; Zoltai and Tarnocai, 1975; Rostad et al., 1976; Slater, 1985; Robinson and Moore, 1999; Robinson, unpubl. data; C. Tarnocai, pers. comm. 1998). J.A. Westgate (pers. comm. in Slater, 1985) determined that ash found in a lake near Wrigley, Northwest Territories, was mineralogically consistent with the White River ash. This paper provides a revised distribution of the White River ash, based on field observations of the ash in peatlands. The White River ash is the only documented macroscopic ash in this region during the late Holocene. The author has never seen the ash, nor has it been reported in the Mackenzie Valley except in peatlands and lakes.

EXTENDING THE WHITE RIVER ASH DISTRIBUTION

Data were compiled from published accounts of the ash in the Mackenzie Valley, from unpublished sources, and from field surveys to revise the distribution of the eastern lobe of the White River ash (Fig. 2).

Field surveys showed the presence of the White River ash in the upper metre of peatlands of the upper Mackenzie Valley as far east as 116 16' W, near the western shore of Great Slave Lake, over 1300 km from the source (Fig. 2). The ash in peatlands at the easternmost sites is less than 5 mm thick and highly discontinuous, suggesting that the true eastern margin may be approached. The ash was not visible in any peatlands investigated farther to the northeast.
To the north, the ash has been noted in peatlands and lakes near Wrigley, Northwest Territories (Slater, 1985; Robinson, unpubl. data; C. Tarnocai, pers. comm. 1998), yet field investigations of two peatlands 40 km north of Wrigley failed to yield any visual indications of ash. Detailed investigations of peat cores collected near Norman Wells, Northwest Territories, also failed to reveal visible ash. MacDonald (1983) and Kershaw and Gill (1979) report the White River ash near Macmillan Pass on the Northwest Territories–Yukon border, over 300 km southwest of Norman Wells. Kindle (1945:21) reported that a “white volcanic ash ranging from 2 to 4 inches thick” mantles much of the Teslin-Macmillan Pass area. The ash in that region is reported to be widespread in the valley bottoms, but is not seen on the slopes.

The ash has been noted as a thin, discontinuous layer in a peatland about 17 km north of the Alberta border (60° 10′N, 119° 43′W). Investigations of two peatlands 30 and 50 km further south did not show any visible ash. Similarly, detailed peat investigations in northwestern Alberta did not reveal the presence of tephra (Reid, 1977; L. Halsey, pers. comm. 1999). The ash layer has also been reported near Blue River, northern British Columbia (H. Gabrielse, pers. comm. in Fuller, 1986). Hansen (1950) discovered minor traces of ash of unknown source in the “upper levels” of peat deposits along the Alaska Highway in northeastern British Columbia, but it appears likely that this may be the distal end of the Edziza ash (Souther, 1976).

Lerbekmo and Campbell (1969) suggest that the ash covers 324 000 km², and Hanson (1965) calculated a tephra volume of 25 km³. On the basis of the extension of ash distribution into the Mackenzie Valley, it is possible to revise the distribution of the White River ash layer. This new distribution (Fig. 2) covers approximately 540 000 km², with a tephra volume of 27 km³ based upon an extension of Hanson’s (1965) data. Bostock (1952) presented the first isopach map of the White River ash, and suggested that deposits up to 30 cm thick were found as far away as Carmacks, 330 km from the source. A revised graph showing visible tephra thickness and distance from the source is presented in Figure 3. The use of microscopic techniques (Zoltai, 1988) may serve to extend the distribution further; however, if the ash is not readily visible, its utility as a chronostratigraphic marker is diminished.

THE WHITE RIVER ASH AS A CHRONOSTRATIGRAPHIC MARKER

The short time span and constrained timing of volcanic ash deposition, combined with unique physical and chemical
parameters, make tephra layers ideal for use as chronostratigraphic markers. Dawson (1889) used the White River ash layer to infer downcutting of the Yukon River, and Capps (1915) used the thickness of peat over the ash to estimate the timing of the north lobe emplacement. Fuller (1986) was the first to make use of the White River ash as a chronostratigraphic marker in a detailed, process-based study. He used the presence or absence of ash to examine lateral migration, island growth, channel downcutting, and vertical sediment accretion in the channel of the Yukon River over the past 1200 years. In peatlands, where chronological control is always problematic when comparing among sites, the ash has provided a dated base horizon from which to calculate carbon and peat accumulation rates in different peatland forms in the Northwest Territories (Robinson and Moore, 1999) and in the Yukon Territory, however, where the ash is preserved in a wider variety of landforms, its potential use as a chronostratigraphic marker extends to fluvial, alluvial, glacial, periglacial, and aeolian landforms and processes.

In the southwestern Northwest Territories, the preservation of ash only in peatlands and lakes limits its utility as a marker to locations within these environments. In the Yukon Territory, however, where the ash is preserved in a wider variety of landforms, its potential use as a chronostratigraphic marker extends to fluvial, alluvial, glacial, periglacial, and aeolian landforms and processes.

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REFERENCES


